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Constraint Induced Aphasia Therapy:

A Review of Protocols and Findings

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Constraint Induced Aphasia Therapy:

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Dedication

This report is dedicated to my friends and family who have given me their unconditional love and support throughout this process: Shivalika Mehan, my closest confidante who was always close to me even from miles away who support me throughout this process. Tehreem Shahab, who gave me lots of love, laughter, and unconditional support. Maysa Alqaisi, my sister and who I am grateful for every day. Yasmeen Alqaisi, my sister whose wisdom and love never cease to amaze me. My parents and brothers who have guided and supported me throughout graduate school and in life. I am so grateful for all of your constant reassurance and compassion.

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Abstract

Constraint Induced Aphasia Therapy:

A Review of Protocol and Findings

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Abstract: Constraint-induced aphasia therapy (CIAT) is an intensive speech and language treatment approach rooted in motor therapy. It is most often utilized to treat post-stroke language loss. The underlying framework for this treatment is based on the concepts of shaping, intensive practice, and prevention of compensatory strategies. Current evidence reveals that modest evidence exists supporting treatment efficacy of CIAT in chronic aphasia and more recently, its use in the acute phase has been investigated as well. Research supports the role of intensity in the treatment of chronic aphasia and the importance of constraint should also be explored. This report reviews the current evidence concerning CIAT and its findings as well as the efficacy of different treatment protocols.

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Introduction

Aphasia is an acquired neurological multimodal language loss, which usually occurs after focal damage in the cerebral areas that typically hold language. This damage is primarily due to ischemic and hemorrhagic strokes, however it can also be caused by traumatic brain injury (TBI), brain tumors, brain infections, and other progressive neurological disorders. (McNeil & Pratt, 2001). The National Stroke Association reports 80,000 new cases of aphasia per year in the United States and the National Institute of Neurological Disorders and Stroke estimates that 1 million people in the United States are living with aphasia (Engelter et al., 2006). Immediately following a cerebral vascular stroke, the patient's verbal communication is severely limited. Spontaneous recovery of language function is typically completed by year one post recovery, which is also when the symptoms of aphasia diminish (Berthier & Pulvermüller, 2011). This idea parallels movement disorders, as it was conventionally believed that regaining movement of a neurologically impaired limb one year post stroke was not possible. Post-stroke, 30%-38% of patients experience a severe speech production and comprehension deficit and 40%-60% of these patients maintain these impairments into the chronic phase (Pedersen, Vinter, & Olsen, 2004). The loss of the ability to effectively and productively speak often leads to social isolation and loss of independence (Carter, Connor, & Dromerick, 2010). The effectiveness of speech and language therapy during the chronic phase requires more research and evidence, however some preliminary studies have shown therapeutic effectiveness of treatment even in the chronic phase (Allen, Mehta, McCLure, & Teasell, 2012). Current evidence shows

that intensity of the treatment is perhaps the most important element to speech and language treatment post 6 months onset of aphasia (Carter, et al., 2010). This report will explore how effective Constraint Induced Aphasia Therapy (CIAT) is in the treatment of acute and chronic aphasia and which elements of this therapy are most essential.

Constraint Induced Movement Therapy

Constraint Induced Movement Therapy (CIMT) is a relatively new family of rehabilitation for recovery of extremity motor function after a cerebrovascular accident (Taub, Uswatte & Pidikiti 1999). One of the underlying theories driving successful constraint induced motor treatment is learned nonuse. This idea originates from a suppression of movements of the neurologically impaired extremity during the acute period of recovery. This is a conditioned behavior; since the movement of the limb is poor and the patient often fails in utilizing it successfully, they develop compensatory strategies such as asking family for help. The behavior is rewarded, thus increasing the behavior. A primary tenant of CI movement therapy is having the patient overcome this learned non-use in order to successfully use both limbs to complete a desired activity (Taub et al., 1999). The pioneer researcher of CIMT, a behavioral neuroscientist named Edward Taub, founded the theory of learned nonuse. His work is based on research with non-human primates in the early 20th century. The primates were tasked to produce movement with purposeful and intent using an impaired arm. Since the primates were successful, these preliminary studies suggested that the limitation of mobility may not be caused by the lack of ability but actually due to disuse (Taub & Heitmann, 1977).

In his research, Taub noticed that monkeys continued to attempt to use a neurologically impaired limb immediately after the injury even though the functioning was significantly deceased (Taub et al., 1977). Expectedly, the attempts to use the limb in the beginning stages are unsuccessful and this serves as a

punishment stimulus for the monkey which in turn decreases the attempts to use that limb until the use of that limb is completely deceased (Taub, 1980). The motivation to utilize the impaired limb is also significantly decreased because the primate learns compensatory strategies with the other limb(s). Successful attempted movements using the non-impaired limbs reward the monkeys, leading to an increase of this behavior. Interestingly, Taub also found that the primates who had both impaired limbs did not lose motivation to use these affected limbs and they were able to use them once they progressed into their recovery period (Taub, 1980).

Taub theorized that this may also apply to human patients after a stroke or a brain injury in which the patient in unable to use the impaired limb (Taub et al., 1977). After a stroke, when the central nervous system is in the initial sate of shock, learned nonuse develops by multiple unsuccessful attempts to use the impaired limb (Taub et al., 1993). If the patient retains enough neural substrates that provide the foundation for movement, then after the shock period has subsided, they can overcome this learned nonuse. By constraining the use of the affected limb and forcing the overuse of the impaired limb, a cortical reorganization occurs which helps in the recovery and rehabilitation of the movement of the impaired limb (Taub et al., 1993).

The learned non-use has negative long-term effects on the patient, such as compensating with the stronger limb and becoming accustomed to avoiding use of the affected limb. This behavior becomes habitual and combining this with the accompanying cerebral changes further the motor deficits in the affected limb.

(Taub et al., 1993) This becomes a cyclical pattern in which a patient decreases use of the impaired limb leading to a decrease of its functional in use. In turn, this leads to a change in the neural networks, which control that extremity, as it becomes to adopt rather than better the motor function of that limb. Because of these series of events, Taub theorizes that the opposite must be true as well. Thus, increasing the use of the impaired limb can improve the functional use of it and the neural network will reorganize to support movement rather than suppress it (Taub, 1980). The constraint usually involves using the more impaired limb during 90% of walking hours for all tasks and intense training of the limb 6 hours a day 5 days a week while keeping the stronger arm or leg in a sling or mitt (Taub et al, 1993).

There are three main features of CIMT, which are a unique and novel addition traditional motor therapies (Taub et al, 1993):

1. *Constraint*: This involves restraining the use of the patient's stronger limb, forcing the participant to utilize the impaired limb. This usually involves a mitten for the hand and a brace else for the leg.

2. *Real world engagement*: The patient has to work with intention in real world, highly functional tasks during treatment.

3. *Intensive practice*. This involves repeating the tasks, which includes allowing the patients to plateau within the session, and increasing the difficulty levels and holding treatment sessions for an extended period of time, most days of the week. Most protocols involve treatment for 2-3 weeks, 6 hours a day, for 5 days a week.

Taub and colleagues conducted this pilot study exploring constraint induced movement therapy on the very first human participants in 1993. The participants included nine patients with chronic stroke. A sling restrained each participant's unimpaired arm during the walking hours of the day for two weeks. During ten of the fourteen days, participants were given six hours of direct treatment by practicing use of the impaired arm as instructed by the clinician (Taub et al., 1993) Treatment included functionally relevant tasks such as card games, playing board games, and participating in sports depending on the participant's preferences. The participants were required to exclusively use the affected limb for the assigned activities. There was a control group that received more traditional physical therapy including at home exercises. The control group's treatment involved more passive use of the impaired limb rather than incentivized functional movements (Taub et al., 1993). The results of this pilot study showed significantly higher improvement by the experimental group than the control group. The CIMT participants showed significant improvement on all of the outcome measures and the improvements were maintained when the participants were assessed two year post treatment. The control group exhibited smaller gains and these were not maintained during the follow up assessment (Taub et al., 1993).

Since the pilot study, in the last 20 years, substantial evidence has been accumulated exploring the efficacy and limits of CIMT, which include the original protocol as well as modified ones specifically for rehabilitating the use of a limb during a chronic stroke in people with hemiplegia (Hakkennes & Keating, 2005). There have been more than 120 studies investigating CIMT including one

randomized control study (Wolf et al., 2006) and a placebo-controlled study (Taub et al. 2006). In 2015, a review was released which summarized 44 smaller trials of CIMT (Kwakkel, Verbeek, Wegen, & Wolf, 2015). Even though many of these studies used a modified version of the original protocol, the findings from the studies and meta-analyses showed that both the original protocols and the modified versions showed substantial improvements and results in the outcomes of the impaired arm in terms of daily life activities, patient self-reporting, and generalization to home life (Kwakkel et al., 2015). The ability of motor function is assessed by the researchers pre and post treatment and the assessment most often utilized is the Motor Activity Log (MAL) (Uswatte, Taub, Morris, Light, & Thompson, 2006), which included observations of activities of daily living and how the impaired limb performed in these tasks. The MAL also assesses how well these improvements generalize into the home environment and if the improvement is maintained for two years post treatment (Uswatte et al., 2006).

Research shows that CIMT is one of the most effective treatment strategies in motor intervention in impaired limbs post stroke. It is important to note that effects were limited to motor ability and it did not have any significant effects on sensibility, pain, quality of life, and grip strength post intervention (Alberts, Butler, & Wolf, 2004). It should also be noted that the randomized controlled trials in which the only distinct factor between both groups was simply having the experimental group wear a mitt and no structured exercise program did not have show any improvements in the movement of the impaired limb (Kwakkel et al., 2015). Thus, the modifications to the original protocol include the addition of

shaping, which although was not part of the original protocol, later became a tenant to constraint induced motor treatment. Other variations include different forms of restraint such as the use of gloves and mitts rather than a more restrictive brace. The protocol, which showed the most significant gains, involved shaping, repetition of exercises, and instructions for behaviors, making these the most essential aspects of CIMT (Kwakkel et al., 2015).

Although post-stroke patients were primarily discussed in this report, there have also been modifications to CIMT for use with individuals with multiple sclerosis (Mark et al., 2013), individuals with traumatic brain injury (Shaw et al. 2005), and with younger children with cerebral palsy (Taub et al., 2011). Constraint induced movement treatment is not without its limitations as it is not very effective for acute patients and in the very early stages of recovery post-stroke. CIMT is also very intensive, requiring a lot of both the patient's and therapist time, which many rehabilitation units do not have and the long hours of treatment may fatigue some patients.

Constraint Induced Aphasia Therapy

The substantial evidence that motor skills can be improved with chronic stroke led to the idea that perhaps language impairments can also be improved in chronic stroke by the underlying framework of CI therapy. Pulvermuller and colleagues introduced the idea of CIAT in 2001, by adopting the CIMT principles and extending it to aphasia treatment (Pulvermuller et al., 2001). When extending the CIMT to post-stroke speech and language therapy, it is essential to evaluate what the constraints will be and how to implement massed practice in order to engage the specific impaired language functions (Pulvermuller et al., 2001).

The researchers of this study theorized that learned nonuse can also be applied to language impairment after a substantial neurological injury. They hypothesized that extended use of the compensatory strategies is a verbal form of learned nonuse. The nonuse of verbal speech output can be exasperated by the negative reinforcement by other people to their verbal communication attempts (Pulvermuller et al., 2001). Since verbal output can seem embarrassing or effortful and difficult for people with aphasia, they begin using compensatory strategies such as gesturing or remaining silent. Very often, a family member or caregiver speaks for the person with aphasia, which further decreases their incentive to speak (Croteau & Le Dorze, 2006). This can also lead to avoidance of social situations and concurrent psychological issues as well (Szaflarski et al., 2008). Constraint induced aphasia treatment suppresses these compensatory strategies which include gestures and drawings, often used by aphasic patients and forces them to use verbal communication (Pulvermuller et al., 2001). They utilize these strategies since they

rely on the least effortful method to communicate. If they do use verbal output, they often depend on short familiar phrases and words and avoid speech, which they anticipate to be difficult to produce (Szaflraski et al., 2008).

The failure of not being able to complete an attempted motor activity diminishes the use of the attempted motor activity and serves as a punishment. While using one arm or leg is not the most efficient way, if the attempted motor activity is successful it is then rewarded. The failure to complete the motor activity or punishment for attempting a motor activity and reward for using the non-affected limb ends up producing the learned nonuse effect (Taub et al., 1993). When enough time has passed, and if it is possible to have use of the impaired limb then the learned nonuse can become permanent in post-stroke patients. This also transfers to language output; the learned nonuse results from the punishment, which is the failure of complex verbal production and the reward of using alternative communication modalities (Pulvermuller et al., 2001). CIAT is designed to suppress the learned non-use. It should be noted that CIAT is not contradictory toward any treatment approach that focuses on other communication modalities, as this can also be utilized to enhance verbal communication (Pulvermuller et al., 2001).

In this pilot study, patients with chronic aphasia were assigned to two groups conventional aphasia therapy and the new constraint induced aphasia therapy. CIAT includes intensive practice, consecutively, for a short period of time. The participants are constrained to only use speech and not allow them to use gestures, or other communicative acts (Pulvermuller et al., 2001). Both of the

groups were matched for the intensity of treatment although the length varied and length of treatment. Patients in both groups received the same amount of treatment (30 to 35 hours) as 10 days of massed-practice language exercises for the CI aphasia therapy group (3 hours per day minimum; 10 patients) or over a longer period of 4 weeks for the conventional therapy group (7 patients). Results showed that CIAT yielded significant improvements as measured by standardized assessments, self-ratings, and blinded observer ratings of the patient's functional communicative effectiveness than the conventional aphasia treatment (Pulvermuller et al., 2001).

Extending the constraint induced approach to aphasia therapy is more subtle and difficult because 1) there are no physical constraints to implement in the therapy setting 2) honing in on the area to engage the functions which are affected by the patient's brain lesion is not apparent (Kirmess & Maher, 2010). Since most people with aphasia tend to use the communication method which is most easily accessible and requires the least amount of effort. They will often resort to gestures, or gesticulation instead of using the effortful and tedious spoken language. Constraining these compensatory strategies, both verbal and non-verbal, is crucial to the success of constraint induced aphasia therapy (Meinzer, Djundja, Barthel, Elbert, & Rockstroh, 2005).

In terms of verbal compensatory strategies, it is essential to constrain overused utterances and induce the use of more complex utterances and phrases in verbal production (Meinzer, Rodriguez, & Rothi, 2012). During treatment, it is also crucial to have the patient utilize words outside of their "crutch" or "go to" words. It is important to understand however, that constraint of these more accessible

communication methods can cause frustration and a loss of motivation to participate in therapy. An important aspect of therapy is active engagement, so it is important to use a very gradual transition or hierarchy and challenging the patient slowly (Meinzer et al., 2012). It would be advantageous to provide a gradual transition starting from the patient's communication strengths and taking small steps to progressively work towards improved verbal production. This approach of taking small steps and working up towards the patient's ability is referred to as shaping and the steps are referred to as successive approximations (Dromerick et al., 2009).

Another important tenant of constraint induced aphasia therapy is that the setting should be tailored and relevant to the real-word communication needs the patient has. It should be functional and ideally the verbal output should be relevant to the patient's everyday needs (Meinzer et al., 2012). This information can be gleaned from interview, observations, and assessments with the patient. In the pilot CIAT study, the 17 subjects that were recruited had post-stroke chronic aphasia and had reached a "plateau" during their conventional speech therapy (Pulvermuller et al., 2001). All of the participants were monolingual and had aphasia because of a singular stroke, which affected the left middle cerebral artery. They also had a consequent lesion in the perisylvian areas, including parts of the frontal, parietal, and temporal lobes (Pulvermuller et al., 2001).

The participants were matched for age, sex, education level, handedness, origin of aphasia, number of months after onset of the disease, aphasia syndrome and its severity, language profile at therapy onset, and number of therapy hours

given. The participants did differ on the time after stroke, which was significantly longer in the group receiving constraint induced aphasia therapy. All of the participants were diagnosed with a moderate aphasia and the types included Broca's, Wernicke's, transcortical, conduction, and amnesic (Pulvermuller et al., 2001).

Treatment involved following instructions, completing sentences, naming, repetition and patient preferred conversation. Treatment was administered for three to fives weeks, which was an average of 33.9 treatment hours. The total number of therapy hours was the same for both groups, but the frequency and intensity differed as CIAT is a more intensive treatment (Pulvermuller et al., 2001). The participants were assessed on the four subtests of the Aachen Aphasia Test (AAT) (Graetz, de Bleser, & Willmes, 1992), one day pre and post treatment due to the high test-retest and inter-rater reliability. The scores showed a statistically significant improvement in this outcome measure. The questionnaire of Communicative Activity Log (CAL) (Pulvermuller et al., 2001), which is a language assessment developed to parallel the Motor Activity Log (MAL) was also administered. The CAL includes both self-ratings and observations by clinicians and therapists. It was administered to understand patient's use of verbal language in daily life. The group that received constraint induced therapy showed a significant improvement on this assessment after the 10-day treatment and the group that received conventional aphasia treatment did not show a significant improvement. Patients reported a significant increase of 30% of communication in everyday life after treatment (Pulvermuller et al., 2001).

Patients who received conventional aphasia treatment did not show a significant improvement on this measure. As measured by blinded clinicians ratings, the amount of improvement in everyday communication was seen in 7 out of 10 patients (Pulvermuller et al., 2001). There was an improvement of language performance in chronic aphasia after stroke with intensive constrained induced aphasia therapy in a few days. After 32 hours of treatment in 10 days, substantial improvement occurred in language performance in everyday life (Pulvermuller et al., 2001). This pilot study suggests that improvement can be made post the plateau or spontaneous recovery period, which generally lasts one year.

The brain is able to be so plastic that language may still have the capacity to improve after stroke in a short amount of time, which helps shape the direction of future speech and language therapy in chronic aphasia (Pulvermuller et al., 2001). The results of the pilot study show that some basic principles of constraint induced motor therapy can be successfully transferred to constraint induced aphasia therapy. This includes intensive treatment during a short amount of time and less frequent training which is referred to as the massed-practice principles, use of constraints which force the patient to perform normally avoided actions, and the behavioral relevance principle, which involves using treatment scenarios that are functional and relevant in real life.

Treatment Protocols

Before every session, the clinicians should develop an individualized linguistic hierarchy. These individualized programs are designed to determine which cues would be beneficial to the player, their linguistic weaknesses and strengths, select behaviors, and highlight a language goal (Meinzer, Elbert, Djundja, Taub, & Rockstroh, 2007). These programs were determined by the pre-treatment assessment Boston Diagnostic Aphasia Exam – Third Version (BDAE-3) subtests (Goodglass, Barresi, & Kaplan, 1983). While administering these subtests, the therapists note the cues were most helpful to the participant. During the assessment, the clinicians also note the non-verbal gestures and behaviors most utilized by participant, which they will have to constrain during treatment. The therapists also selected one or two language goals that the participant demonstrated weaknesses in (Meinzer, et al., 2007). The first treatment session also include clinicians adjusting the constraints and targets. The constraints should be created with three main tenants, which are: the shaping and the rules of the game, reinforcement contingencies, and the difficulty of the material. Tracking the responses to cueing is essential in planning treatment (Meinzer, et al., 2007).

The therapeutic game activity includes small groups (usually 2-3 people and the therapist) with a set of 32 cards consisting of 1 of 16 pictures on one side and there were two copies of each card in the set (Pulvermuller et al., 2001). At the beginning of the game, the therapist distributes card pairs that show objects, words, drawings, or photographs of function everyday living. (Meinzer, Rodriguez, & Rothi, 2012). The cards increase in complexity, which is required to shape the difficulty of

the game (Meinzer et al., 2007). The cards should fall into certain categories such as certain objects which have descriptions which have low-or-high frequency words and cards which depict items with phonologically similar names testing their precise articulation and cards depicting the same item with varying colors and numbers which require the client's ability to use more lengthy descriptors (Meinzer et al., 2007).

Every person receives cards and no two players have the same card pair (Meinzer et al., 2012). Each person has cards placed in front of him or her along with barriers so no other players can see the cards (Meinzer et al., 2012). Each player takes a turn by taking one of their own cards and asking another participant if she has the same card for a match. Both of the participants must use verbal output during the exchange (Meinzer et al., 2012). They must address the other player by name and then request a card that matches their card. The goal is to create as many matches as possible. The player who was addressed by the first player must check to see if they have the request card or not. If they do have the card, then they should hand it to the player who asked for it. If they did not have the requested card, then the player is tasked to explicitly state that they do not have the card. The only valid communication in the game is spoken words or sentences. Other modes of communication such as gesturing, pointing, gesticulating were not allowed and would not count in the game. This is what is to be considered a constraint and they force the participants to utilize spoken language and challenge themselves in the game.

The individual constraints for each participant are based on the pre-treatment verbal skills (Meinzer et al., 2007). An example of this is if there are two participants in the game and there is Patient 1 who has a non-fluent type of aphasia may start off by being allowed to use articulation approximants of the expected utterance and shorter utterances can also be accepted. Patient 2 who is less impaired can be required to fulfill the entire criterion such as use of clear articulation, using politeness ("please…), and correct grammar (Meinzer et al., 2007). In the Maher et al. (2006) treatment study, the constraints were much more strict and in one modification they required the players to sit on their hands to not allow gesturing, while other trials allowed gesturing. In many of the protocols, there is another therapist there to provide prompting and reinforcement. It is essential to provide positive reinforcement for verbal expression. This reduces non-productive utterances, stereotypies, circumlocutions, and paraphasias (Meinzer, Steftau, & Rockstroh, 2007).

The materials needed for the game include picture cards, which showed objects that had either: 1. A common name with high frequency, 2. A less common name, 3. A phonologically similar name to another depicted object on other cards being used in the game such as "pin" and "bin" and other minimal pairs (Meinzer et al., 2012). The cards should either be black and white pictures of a single objects or pictures of different objects with varying colors, actions, or numbers. These are considered to be more complex cards (Meinzer et al., 2012).

As the game becomes more complex and the participants level out of the simpler cards more constraints are placed to force the participant to utilize even

more advanced verbal communication. An example of this is if there is a picture which showing the color and minimal pair (ex: red/yellow pin/ bin). The minimal pair aspect forces the participant to use the most accurate and precise articulation to ask for the object or respond to someone who asked for the object. The color aspect forces the participant to use an adjective in order to successfully complete the game and to collect cards (Meinzer et al., 2007).

Active engagement is another important tenant of CIAT as it is more participant-driven rather than therapist-driven, which is unlike other treatment protocols. This is completed by requiring the participants to make an effort to verbally communicate and actively participate. The communication protocol calls for a very natural conversation that the participant may have with family or friends. During the therapeutic game, the content of the verbal production is not predictable by the other participants, which forces them to actively listen and engage. The communication during the therapeutic games also involves different forms of communication including multi-directional and bi-directional (Meinzer et al., 2007).

Another very important tenant of CIAT is massed or intense practice. In treatment, the intensity is defined by the ratio of therapy hours per week, and the amount of time between the sessions. Increased intense treatment helps with new task acquisition and generalization of the skills. CIAT intensity should be around a 12:1 ratio of treatment hours to weeks while most other aphasia therapy is 2:1 (Meinzer et al., 2012).

Shaping and Rule Constraints

As time progresses within the game and across treatment, and the players linguistic skills improve, the constraints and performance criterion increased as well. The cards can begin from very high frequency words, which are easy to recall and articulate up until cards that depict minimal pairs and objects with color and number variations, forcing more precise articulation and descriptions. This is termed shaping, in which the players level out of their highest production skills and increase progressively to higher level constraints and acceptability requirements (Meinzer et al., 2012).

During the beginning of treatment, any verbal productions, even approximations are allowed by the therapist. As the game progresses, the verbal outputs were constrained by the therapist. These constraints included explicit verbal rules and directions given by the therapist (Meinzer et al., 2007). These included shaping and modeling such as requiring the participants to use the first name of the other participant who they were addressing, using politeness such as "*please* give me chair" and the usage of articles, such as "give me *the* candle" or "give me *three* muffins." As participants advance through the levels, the entire sentence is required instead of simply one or two word sentence phrases. For example, they are tasked to completely state, "Mrs. Smith, can I please have the two small golden muffins?" Reinforcement contingencies were related to the level of performance of each patient. Patients, which were on the lower performance capabilities, were provided more reinforcement. Anytime the person obeyed one of the constraints,

they were given positive reinforcements; however higher performing patients are given reinforcements only for satisfying all of the constraints (Meinzer et al., 2012).

Wooden cardholders are also important to include so the participants have a horizontal layout of cards as well as a barrier from the other participants. Post-stroke participants may also have motor impairments and having a cardholder is helpful to play the game (Meinzer et al., 2012). Although in the original protocol, participants are completely obstructed so they cannot see the other players or clinicians, adjustments were made so that the wooden holders would only partially obstruct the view and the players could see each other (Meinzer et al., 2007). This adjustment was made for two reasons which were so that the participants could learn how to inhibit non-verbal gestures without an unnatural obstruction as well as the therapeutic environment should resemble a natural conversational environment (Pulvermuller & Berthier, 2008). Since one of the essential elements of CIAT is real world application, it is important to emulate that environment and the participant should get the social feedback that their message is being positively received.

Before each therapeutic session, the therapist instructed each player about his or her linguistic goals during that session. Each participant had their own levels of constraints and cueing, which the therapist provided during the session (Meinzer et al., 2012). To provide incentives, some clinicians awarded a point for each round, with prizes at the end of each day to the player with most points. These incentives were intended to increase the participants' interest in the treatment, and many of them seem to enjoy the competition (Pulvermuller & Berthier, 2008).

Chronic Aphasia

Szaflarski et al. (2008) explored the effects of Constraint Induced Aphasia Treatment when it compared to no intervention in patients with chronic (one year post stroke) aphasia in a single-blinded RCT. Twenty-four participants were recruited who were randomized into two groups: 14 participants were assigned to group receiving CIAT and 10 participants receiving no intervention. The CIAT group received treatment for 4 hours a day for 10 consecutive weekdays for a total of 40 treatment hours (Szaflarski et al., 2008). All of the participants received the following assessments: the Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 2001), the Controlled Oral Word Association Test (Ruff, Light, Parker, & Levin, 1996), the Semantic Fluency Test (SFT), the Complex Ideation subtest from the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass et al., 1983), the Peabody Picture Vocabulary Test III (PPVT III) (Dunn & Dunn, 1997) and the Mini-Communicative Activities Log (Mini-CAL) (Pulvermuller et al., 2001).

The clinicians were blinded during the assessment to ensure validity. These assessments were administered pre-treatment, post-treatment and 12 weeks post treatment. Clinicians completed an extensive training program (4-6 hours) to ensure consistency of the intervention across all of the clinicians (Szaflarski et al., 2008). Clinicians also observed the sample videos, which showed the CIAT intervention and were trained about the hierarchy of cues removing the levels of support, starting from imitating the clinician to a simple verbal reminder. On the first day of intervention the other blinded clinicians kept track of the cues and their success rate with the participants during treatment. A treatment plan was created

which identified each person's beginning linguistic strengths, a suggestion of the hierarchy of prompting cues, which behaviors should be constrained, and specific language goals (Szaflarski et al., 2008).

This treatment plan was provide to and reviewed with the clinicians before the second day of treatment. After the second day, the clinicians gave individualized support at the linguistic level of each participant and continued to track data (Szaflarski et al., 2008). The individual programs were adjusted daily if needed. During the beginning of each treatment session, the clinicians reminded every participants of the constraints and the goals which have been established for them. The goals also included a linguistic complexity hierarchy so if a participant was strong in producing verbs but showed weakness in producing nouns, their specific goals may be to create a three-word utterance including at least one noun (Szaflarski et al., 2008).

Findings from the study showed that the results from the CIAT group were not statistically significant. However, there are still treatment effects and factors to take into account, and the treatment effects are in line with the original pilot study (Pulvermuller et al., 2001). There were a small amount of participants had a highly variable level of post-stroke aphasia making the comparison of two comparison groups difficult. The observed effects are that there was still treatment effect, but there was not enough to prove statistical significance. It should also be noted that there was a statistical significant improvement on the mini-CAL between the CIAT group compared to the control group. This indicated that the participants perceived

a significant amount of improvement with their performance, which is an important motivating factor and gives optimism to a population (Szaflarski et al., 2008).

2015 compared the effectiveness of two intensive aphasia treatment methods: Constraint-Induced Aphasia Therapy (CIAT; Pulvermüller et al., 2001) and a semantic therapy (BOX; Visch-Brink & Bajema, 2001). The study included nine patients with fluent aphasia in the chronic phase and they were randomly assigned to either group. Both treatment groups showed statistically significant improvement in verbal production. The semantic treatment however showed more improvement on Amsterdam Nijmegen Everyday Language Test (ANELT) (Blomert, Koster, & Kean, 1995) and one the Communicative Effective Index (CETI) (Lomas, Pickard, Bester, Elbard, & Finlayson, 1989). All nine of the participants showed significant improvement on the Aachen Aphasia Test (AAT) (Graetz et al., 1992). Even further, there were treatment specific gains, with the BOX treatment increasing the semantic capacity of the participants and CIAT increasing the language production and phonology. Most CIAT studies involve non-fluent aphasia, thus this study addressed the fluent type. The findings suggested that intensive treatment does have a significant effect on language production and shows selective treatment effect (Szaflarski et al., 2008).

The sample size was small so the results of this study should be taken with caution. This study shows that people with chronic moderate fluent aphasia of Wernicke's aphasia or transcortical sensory aphasia after a left vascular lesion can strongly benefit from intensive CIAT or BOX (Szaflarski et al., 2008). These two treatments differ in their theoretical construct or foundation as the BOX therapy is

impaired based and IAT is constraint induced. The content also differs as BOX therapy focuses on semantics and CIAT focuses on improving verbal communication. The protocol of the treatments is also different as BOX treatment focuses uses individual one-on-one treatment and CIAT uses group treatment. Everything else was matched in terms of the therapy regime including the duration, frequency, and intensity (30 hours over 10 weekdays) (Szaflarski et al., 2008).

Acute Aphasia

The effectiveness of CIAT in acute aphasia has been sparsely investigated and in most studies there is a modified version of the protocol used. There needs to be more research in CIAT in the acute stage of aphasia recovery as the body of evidence for aphasia is primary in chronic stroke patients. There have been very few studies to date exploring the effectiveness of CIAT in the acute phase, which is considered to be during 1-2 months post stroke. In the last couple of years there have been an increase in studies exploring this.

The first study was conducted by Kirmess and Maher (2010), which included three participants with acute aphasia. However, they modified the original protocol by dividing the treatments into shorter sessions rather than extended periods of practice and administering the treatment bedside due to the physical fatigue of the patients. The dosage treatment varied from 1.15 to 3 hours a day and a total of 20-30 hours (Kirmess & Maher, 2010). Although they were scheduled for 3 hours a day for 10 days, they had to be more flexible with the scheduling in the acute hospital setting and since the patients stamina level is much lower in the acute stage of recovery, they had to slow for time modifications and shorter treatment sessions (Kirmess & Maher, 2010).

Treatment was modeled after the original pilot study (Pulvermuller et al., 20010 and Maher et al., 2006, which included both group settings and individual settings (with just the speech language pathologist as a communication partner). The assessments used for the treatment sessions included the several subtests of Norwegian Basic Aphasia Assessment (NGA) (Reinvang & Engvik, 1980), the

Western Aphasia Battery (Kertesz et al., 1982) and Test for Reception of Grammar (TROG-2) (Bishop et al., 2009) and the Verb and Sentence Test (VOST) (Bastiaanse, Lind, Moen, & Gram Simonsen, 2002), and Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) (Kay, Lesser, & Coltheart, 1992), the Cookie Theft (CT) picture description (Goodglass & Kaplan, 1972). These assessments were administered pre and post treatment. A questionnaire was also included which had a 5-point scale and open ended questions to assess how the participants experience was with the CILT program.

All of the participants showed improvement in these assessments with the improvements ranging from 5.1% to 23.3% (Kirmess & Maher, 2010). From the clinical questionnaire, all of the participants also reported a positive experience. During the follow up testing, there was an even further increase in the improvement. It is difficult to assess how much of a factor the CILT had and how much of an effect the spontaneous recovery had. However, the researchers attempted to assess this by comparing the writing samples provided by the participants pre- and post- treatment (Kirmess & Maher, 2010). The participants showed significant improvements in verbal productions but not in written production, which suggests there was something specific to the treatment that improved the verbal ability of the participants (Kirmess & Maher, 2010). It is important to note that since there was no control group and the amount of participants was very small, the results should be taken with caution.

Sickert,, Anders, Munte, & Sailer (2013) aimed to investigate how effective the unmodified CIAT is for patients in the subacute phase, since only modified

versions had been utilized with this population. This study included eleven stroke patients with acute aphasia who participated in 30 hours of CIAT over the course of 10 weekdays. Linguistic capability and their communication quality were assed four times: before the control period, pre-treatment, post-treatment, and during the follow up (Sickert et al., 2013). Primary outcome measures include the Aphasia Battery (WAB) (Kertesz et al., 1982) and secondary measures included the Communication Effectiveness Index (Lomar, Pickard, Bester, Elbard, Finlayson, & Zoghaib, 1989) and the Communication Effectiveness Profile (Warner, 2002). The original protocol (Pulvermuller et al., 2001) was utilized and treatment outcomes showed that the improvement of language or communication was not statistically significant, but all of the participants showed a somewhat improved language function or at least stable language function for up to six months post treatment (Sickert et al., 2013).

Ciccone et al. (2016) study compared CIAT with traditional aphasia treatment. Both treatments were administered daily in the acute phase of rehabilitation post-stroke. This study was a prospective, single-blinded, randomized and controlled study with patients who had mild to severe aphasia within 10 days of an acute stroke. The participants were randomly assigned to a treatment with one participant in the CIAT and eight participants in the traditional aphasia treatment (Ciccone et al., 2016). Both groups received treatment with the same intensity, which was for one hour a day for 5 days a week for 5 weeks totaling 20 hours. The outcome measures were the Aphasia Quotient (AQ) subset from the Western Aphasia Battery (WAB) (Kertesz et al., 1982) pre and post treatment 12 and

26 weeks post treatment. The Discourse Analysis (DA) (Kertesz et al., 1982) score and the Stroke and Aphasia Quality of Life Scale (SAQoL) (Hilari, Byng, Lamping, & Smith, 2003) were also used to assess performance post treatment, and 12 and 26 weeks post stroke. Findings from the study show that there was no significant difference between the CIAT group and the traditional individual therapy on all of the outcome measures. This suggests that CIAT, in a group setting, is a viable option for acute stages of recovery (Ciccone et al. (2016).

Woldag, Voight, & Hummelsheim, 2017 explored which key factors, play a role in Constraint Induced Aphasia therapy, specifically in the acute stage of aphasia recovery. It is unknown whether intensity or constraint is essential in being the determining factor for therapeutic success in this phase (Bakheit et al., 2007). This study included 60 patients with aphasia who were enrolled in the study while in the acute phase of recovery. The participants were randomized into three groups which were: 1) traditional CIAT group for 3 hours everyday for 10 days, totaling 30 hours, 2) conventional aphasia treatment group which received the same intensity of treatment but with no constraints, and 3) a control group which received one-on-one treatment twice a day and group therapy totaling 14 hours (Woldag et al., 2017). The patients were assessed pre and post treatment using the Aachener Aphasia Test (AAT) (Graetz et al., 1992) and the Communicative Activity Log (CAL) (Pulvermuller et al., 2001). The outcome measures showed no between-group differences but all of the participants showed significant improvements in the acute phase of aphasia rehabilitation. Thus, during the acute phase, the results shows that the treatment which use 14 hours of individual aphasia therapy in two weeks, which

honed in on the individual linguistic deficits and the group sessions was the most efficient and produced the same results as other treatments (Woldag et al., 2017).

Intensity

It is important to understand the role intensity of treatment plays in CIAT, and if it is an integral aspect of treatment, however most studies do not control for this factor (Meinzer et al., 2012). In 2008, Cherney et al. conducted an evidence based systematic review to explore the effects of intensity in CIAT with individuals with post-stroke aphasia. The purpose of the analysis was to examine the role that intensity played in treatment. Intensity of treatment is very important to investigate in post-stroke aphasia treatment due to the limitations that rehabilitation centers and hospitals have on the amount of treatment patients receive. Constraint Induced Aphasia Treatment is especially intensive, as even the most intensive no-CIAT studies deliver significantly less treatment hours than CIAT. There were ten studies reviewed. Both acute and chronic aphasia CIAT treatment studies were reviewed.

The present review included ten CIAT studies, of which five of them evaluated intensity of treatment (Basso & Caporali, 2001; Denes, Perazzolo, Piani, & Piccione, 1996; Hinckley & Carr, 2005; Hinckley & Craig, 1998; Raymer et al., 2006), and four studies investigated CIAT (Maher et al, 2006; Meinzer et al, 2004; Meinzer, Djundja, Barthel, Elbert, & Rockstroth, 2005; Pulvermuller, Hauk, Zohsel, Neininger, & Mohr, 2005), and 1 study, which is the pilot study, examined both (Pulvermuller et al., 2001). Of these studies, none of them investigated intensity of treatment and/or CIAT for treatment effects in the acute phase of aphasia. Increasing treatment intensity was correlated with significantly higher treatment effects with chronic and acute aphasia in the outcome measures of language deficits in the 68 participants (Cherney et al., 2008). All of the studies, which compared more and less

intensive studies, showed higher effects in the more intense treatment studies (Cherney et al., 2008).

Menzer et al. (2005) also investigated the importance of constraint in the chronic phase of aphasia. The 27 participants receiving CIAT were compared to a group of 12 participants who were treated with Model Oriented Aphasia Therapy (MOAT). Both groups were matched in terms of clinical and demographic characteristics. MOAT utilizes similar tenants to CIAT, which are an intensive treatment schedule, shaping, and family training. However they differ because MOAT does not utilize constraints and is highly individualistic while CIAT is used in a group setting. Assessment utilized in this study was the Aachen Aphasia Test (AAT) (Graetz, de Bleser, & Willmes, 1992) and Communication Activity Log (CAL) (Pulvermüller, 2001), and the Communication Effectiveness Index Development (CETI) (Lomas, et al. 1989). These were given pre-treatment, post-treatment, and six months post treatment. The results showed significant improvement in both the MOAT group and CIAT group across the three outcome measures with no significant between-group differences (Menzer et al., 2005) Treatment gains were also maintained during the 6-month follow up testing. These findings suggest that the intensity of treatment is a very essential tenant of chronic aphasia, however constraint is an aspect that needs further research.

It is important to note that the majority of the participants selected for this study were patients with nonfluent forms of aphasia in the chronic phase of recovery. Most of them also had moderate to severe aphasia and most often the global type of aphasia. When reaching conclusions about this analysis, it should be

noted that the results are most relevant and applicable to individuals with severe chronic nonfluent aphasia. Therefore, conclusions regarding intensity and constraints of treatment are most applicable to individuals with moderate to severe nonfluent aphasia. Future research needs to address, in particular, the impact of treatment intensity for participants presenting with a milder aphasia as well as participants who are categorized as fluent. Similarly for the CILT studies, the majority of participants were nonfluent and moderately impaired, thereby limiting the generalizability of the results in individuals with fluent aphasia and individuals with mild and severe aphasia.

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Enhanced Protocols: CIAT Plus and CIAT II

Meinzer et al. (2005) introduced a modified form of CIAT, which involved including a family member in the sessions, assigning home exercises, and keeping a daily completion log and diary. In pilot study (Meinzer et al., 2005), the unmodified CIAT protocol was compared to the CIAT plus. Treatment lasted for ten days, three hours a day, for a total of 30 treatment hours. The assessments utilized were the AAT (Huber, Poeck, Weniger, Willmes, 1983) and CAL (Pulvermüller, 2001), which were given at pre-treatment, post-treatment and at the 6 month follow up session. All of the participants experienced significant treatment gains across all outcome measures, however there were no significant differences between the CIAT group and the CIAT plus group. It is important to note that only the participants in the CIAT plus group showed continuous improvement during the follow up and maintained these gains 6 months post intervention. This was not observed in the group receiving unmodified CIAT.

Johnson et al. (2014) introduced an enhanced protocol of Constraint Induced Aphasia Treatment that consisted of more than a single exercise, which is intended to increase the efficacy of the treatment. In the present study, there were four native English speakers who had a chronic stoke and showed symptoms of Broca's aphasia. The treatment lasted for 3.5 hours a day for 15 weekdays. The enhanced protocol had three main tenants, which included: 1. Shaping, 2. Strong discouragement of non-verbal gestures or compensatory strategies, 3. Transfer of treatment gains from the study to real-world situations (Johnson et al., 2014). The changes from the original protocol (Pulvermuller, et al., 2001) include the differences in the type of

participants. The present study included all participants with moderate Broca's aphasia based on clinical evaluations and the WAB (Kertesz et al., 1982) while the pilot study only included three of the ten participants with a Broca's aphasia diagnosis. The CIAT II was three weeks long instead of two weeks, which was the length of treatment in the original study, however the lengths of the daily treatments were the same (Johnson et al., 2014).

The primary modification was the increase in the number of exercises from the original protocol (Pulvermuller et al., 2001), which was than only a matching game. The protocol includes five different activities: two warm up repetition exercises which were intended to prime the participants for the rest of the tasks, a modified card matching game, a description of depicted situation, and a role playing activity which is intended to emulate different functional everyday life situations Johnson et al., 2014).

The exercises in the CIAT II required every participant to speak on every round of the game and their responses were timed. The participants were also asked to increase their speech rate. The length of the recorded times were relayed to the participants as a form of feedback often as well as person encouragement to improve from the previous fastest time giving the participant and incentive to reach new personal-best times. Timing and communication of the best personal times of the participants is an integral part of CIMT and the researchers in this study wanted to include it in CIAT as well, as it was not borrowed in the original protocol (Johnson et al., 2014). According to the outcome measures, there was a significant improvement post treatment as well as further improvement 6 months post-

treatment (Johnson et al., 2014) It is important to note that the treatment gains should be utilizes as preliminary findings, as the CIAT II is a new protocol and has only been used with four participants who all had a similar aphasia profile.

Conclusions

Constraint Induced Aphasia Therapy is a promising new treatment that borrows its foundation from the principles of Constraint Induced Motor Therapy (CIMT). The constraints and applicability process in the motor protocol are much more straightforward, however there is a small body of evidence, which show promising treatment for language deficits in post-stroke aphasia. There have been more recent efforts to explore the efficacy of constraint-induced therapy in acute patients. However it is mostly substantiated with chronic aphasia and not many studies with the treatment efficacy in the acute phase. CIAT may be beneficial for patients with chronic aphasia who do not show improvements with conventional aphasia treatment and have reached a "plateau". Although CIAT has been shown to be effective for nonfluent and fluent aphasia types, nonfluent aphasia is disproportionately more represented in the literature than fluent aphasia.

Most studies used assessments to measure improvement include performance on tasks such as naming, repetition, fluency, auditory comprehension, and blinded clinicians rating of communication effectiveness and clinical judgments. Many studies also include the family's perception of the patient's communication effectiveness. Most studies show mild to moderate gains in standardized outcomes measures and measures of functional communication and self-rating scales. Results are not consistent due to the heterogeneous nature of this population and the different aphasia characteristics, which emerge in this population. Most studies also include follow up-data, however they also show inconsistent results, thus the long term benefits of CIAT are not well established.

Additional research is required in order to hone in on what types of aphasia (fluent and nonfluent/chronic and acute) would benefit most from CIAT. Continuing to investigate the role of intensity is also very important. CIAT requires a very intense protocol, which may not be feasible in the real world rehabilitation settings due to the constraints on the clinician's time, financial issues in covering the cost of treatment, and some patients may feel fatigue during the long hours of treatment. Future research should also compare CIAT with other intensive and non-intensive treatments in order to determine how important the constraint aspect of this treatment method is. This may be accomplished by comparing two approaches and which are matched in intensity and treatment materials. It will determine if any treatment gains from CIAT are from the constraint or from the duration and intensity of treatment, the increasing of socialization, or the decrease of compensatory strategies. There have also been modifications to the original protocol in the forms of CIAT plus and CIAT II, which include family training, stricter constraints, and more feedback and reinforcements. However these studies are very limited and it is important to replicate these studies on a large scale to explore the treatment effectiveness. Future research should explore the efficacy of the constraint induced aphasia treatment taking into account the different types of aphasia, lesion sites, chronic or acute phase, and the severity of the impairment. Honing in on what are the important aspects of CIAT, whether it be constraint or intensity is also important to investigate as well as the efficacy of enhanced protocols.

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